Control

3/11/2015 الثلاثاء د. محمد عرفة محاضرة 5

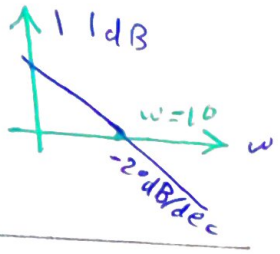
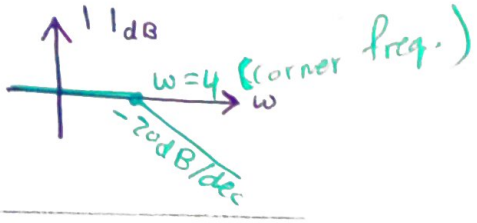
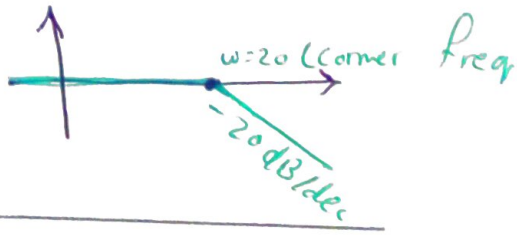
Ex: $GH(s) = \dfrac{10}{s(1+0.05s)(1+0.25s)}$

Draw the Bode Diagram and find ω_{gc}, ω_{pc}, GM and PM

$$GH(s) = \frac{10}{s\left(1+\frac{s}{20}\right)\left(1+\frac{s}{4}\right)}$$

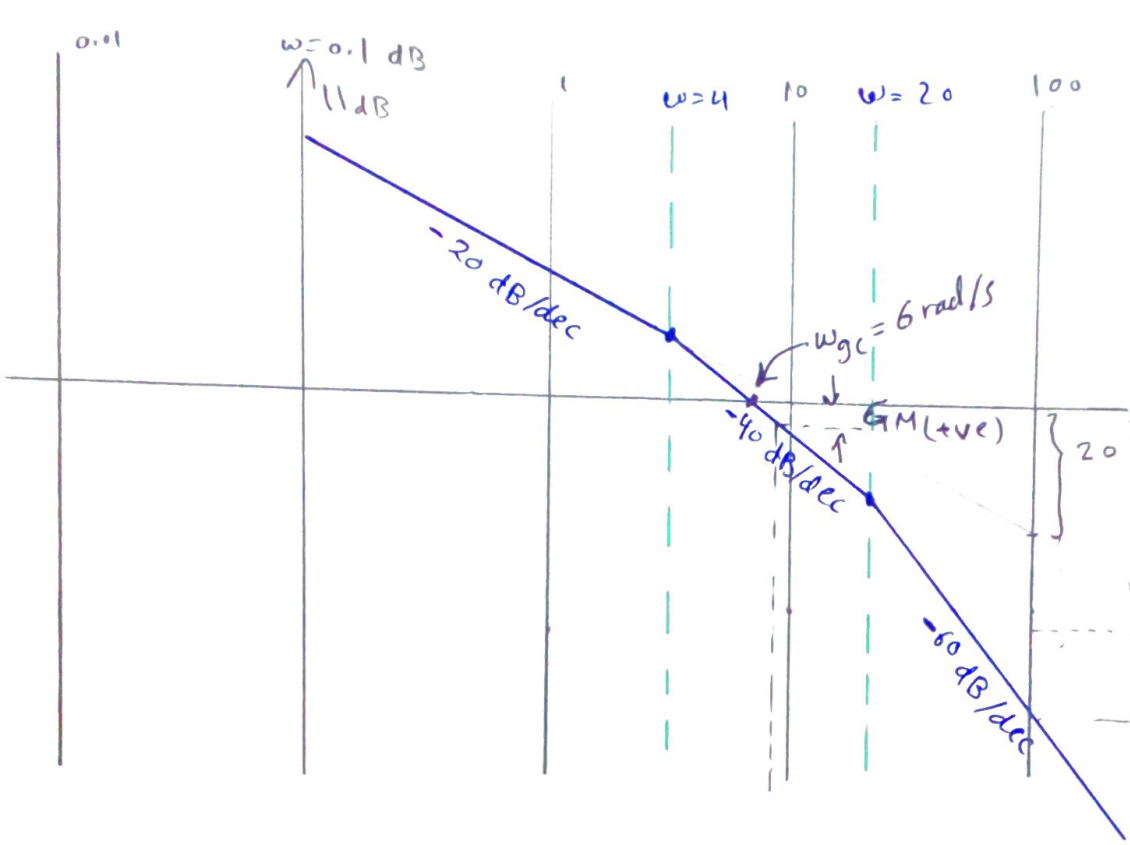
$s \rightarrow j\omega$

$$\Rightarrow GH(j\omega) = \frac{10}{j\omega\left(1+j\frac{\omega}{20}\right)\left(1+j\frac{\omega}{4}\right)}$$

term	$\phi(\omega)$	1 1 dB
$\frac{10}{s} \Rightarrow \frac{10}{j\omega}$	$-90°$	
$\frac{1}{(1+\frac{s}{4})} \rightarrow \frac{1}{(1+j\frac{\omega}{4})}$	$-\tan^{-1}\left(\frac{\omega}{4}\right)$	
$\frac{1}{(1+\frac{s}{20})} \rightarrow \frac{1}{(1+j\frac{\omega}{20})}$	$-\tan^{-1}\left(\frac{\omega}{20}\right)$	

$$\phi(\omega) = -90 - \tan^{-1}\left(\frac{\omega}{4}\right) - \tan^{-1}\left(\frac{\omega}{20}\right)$$

⟹ Turn over



راجع وجوهات المحاضرة السابقة

ملف: Control_Engineering - Lec 4_ graphs

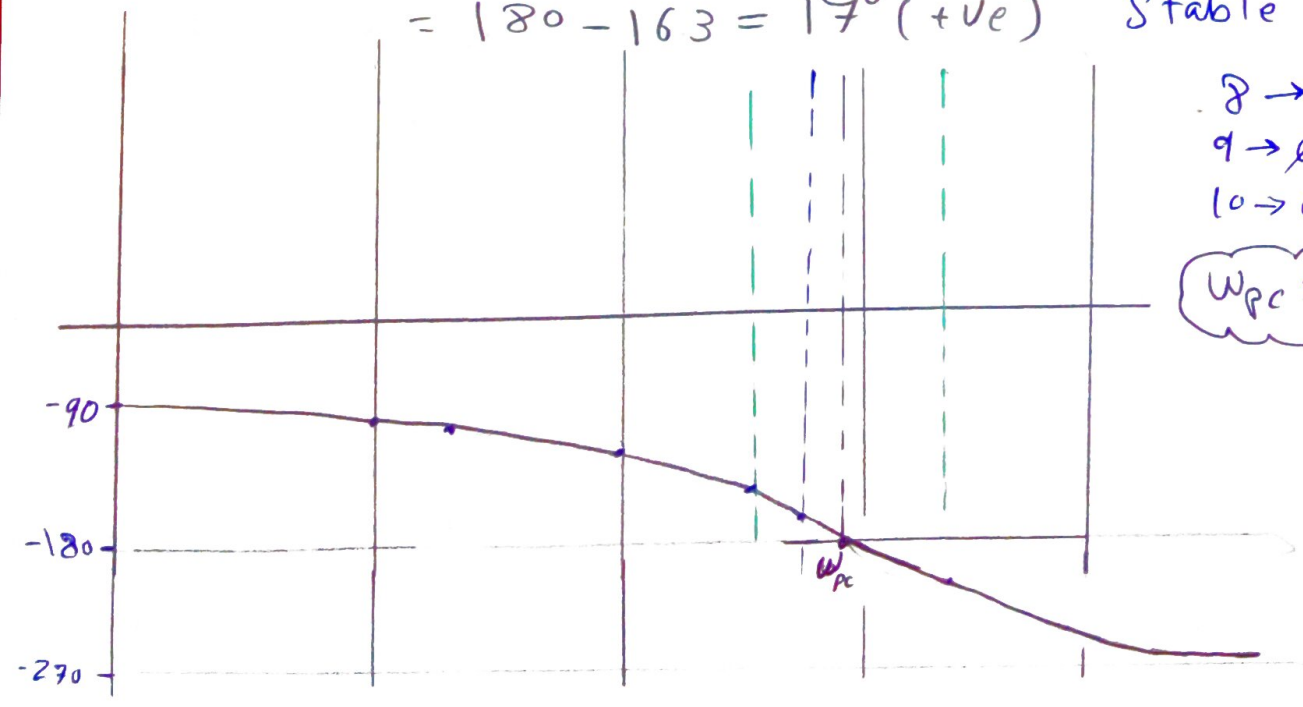
أكمل الرسمة لحد الـ phase مع نفسك
أو راجع الـ graphs المرفوعة من المحاضرة السابقة

ω	0	0.1	0.5	1	4	6 (ωgc)	20	∞
ϕ(ω)	-90	-91.72	-98.5	-106.9	-146.3	-163	-213.7	-270

عند هل المسألة بالرسم

$PM = 180° + \phi(\omega_{gc}=6)$

$= 180 - 163 = 17°$ (+ve) Stable



ϑ → ϕ(ω) = ✓
9 → ϕ(ω=9) = -180.26°
10 → ϕ(ω=10) = -184°

$\omega_{pc} \simeq 9$ rad/s

if you want GM without measuring :-

$$GM = \frac{1}{|GH(j\omega)|} \quad \omega = \omega_{pc} = 9$$

$> 1 \Rightarrow$ stable
$= 1 \Rightarrow$ Critical
$< 1 \Rightarrow$ unstable

$$GM_{dB} = 20 \log GM$$

> 0 stable
$= 0$ Critical
< 0 unstable

بنستنى ω_{pc} اللى بتخلى الـ dB بـ 0

$GM_{dB} \simeq 7\,dB$ exactly

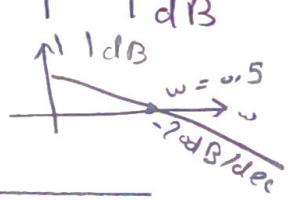
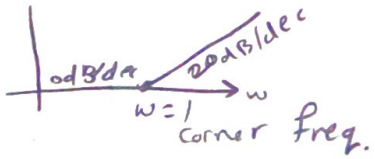
$GM_{dB} \simeq 3\,dB$ graphically

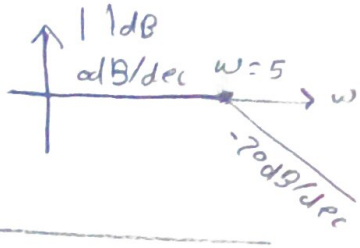
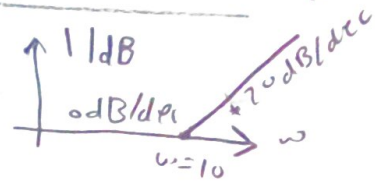
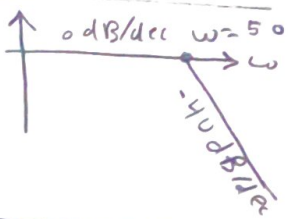
Ex: $$GH(s) = \frac{625(s+1)(s+10)}{s(s+5)(s+50)^2}$$

$$= \frac{(625)(10)(1+s/1)(1+\frac{s}{10})}{(5)(50)^2 s(1+\frac{s}{5})(1+\frac{s}{50})^2}$$

$$= \frac{0.5(1+\frac{s}{1})(1+\frac{s}{10})}{s(1+\frac{s}{5})(1+\frac{s}{50})^2}$$

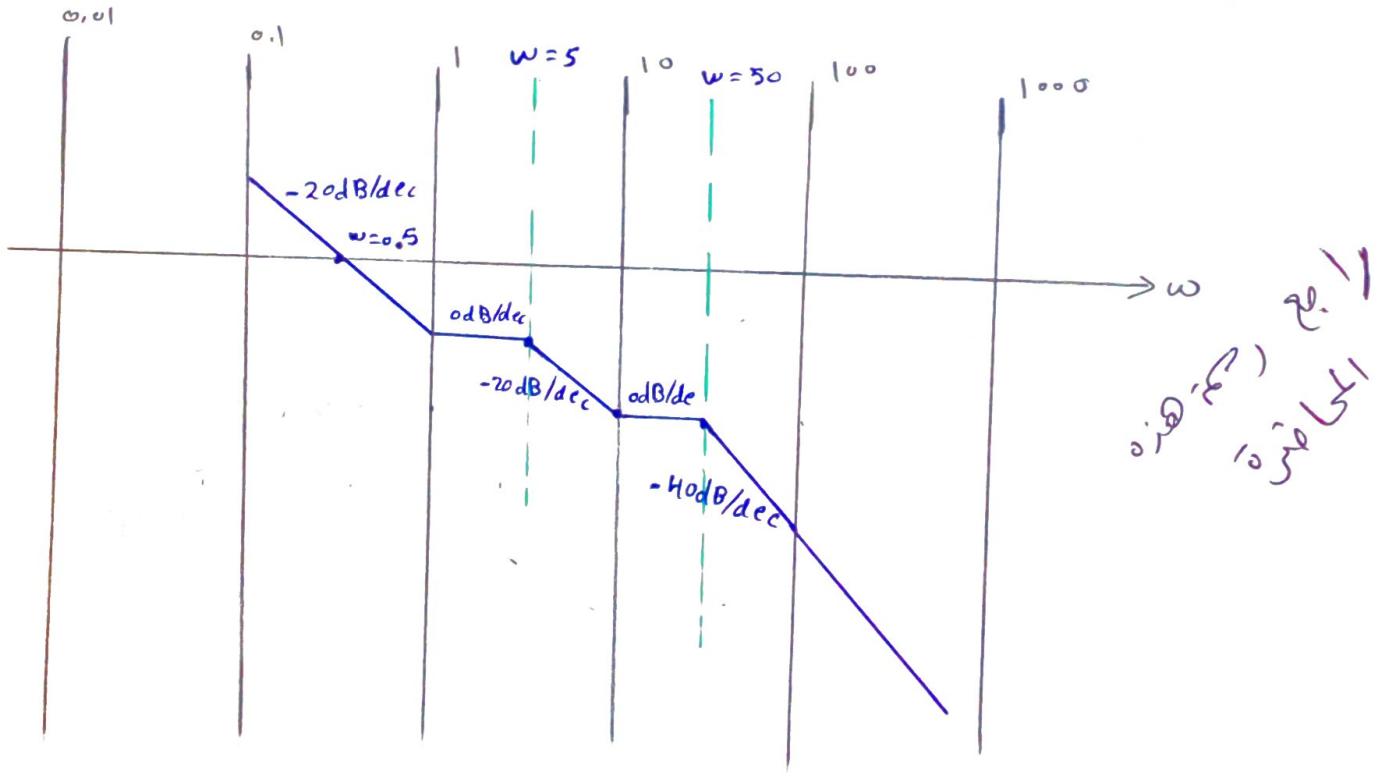
$s \to j\omega \Rightarrow$ $$GH(j\omega) = \frac{0.5(1+j\frac{\omega}{1})(1+j\frac{\omega}{10})}{j\omega(1+j\frac{\omega}{5})(1+j\frac{\omega}{50})^2}$$

term	$\phi(\omega)$	
$\frac{0.5}{s} \to \frac{0.5}{j\omega}$	-90	
$(1+\frac{s}{1}) \to (1+j\frac{\omega}{1})$	$\tan^{-1}(\omega)$	
$\Rightarrow$ turn over		

$\frac{1}{1+\frac{s}{5}} \rightarrow \frac{1}{1+j\frac{\omega}{5}}$	$-\tan^{-1}\left(\frac{\omega}{5}\right)$	
$1+\frac{s}{10} \rightarrow 1+j\frac{\omega}{10}$	$\tan^{-1}\left(\frac{\omega}{10}\right)$	
$\frac{1}{(1+\frac{s}{50})^2} \rightarrow \frac{1}{(1+j\frac{\omega}{50})^2}$	$-2\tan^{-1}\left(\frac{\omega}{50}\right)$	

$$\phi(\omega) = -90 + \tan^{-1}(\omega) - \tan^{-1}\left(\frac{\omega}{5}\right) + \tan^{-1}\left(\frac{\omega}{10}\right) - 2\tan^{-1}\left(\frac{\omega}{50}\right)$$

ω	0		∞
$\phi(\omega)$	-90		



الرسم ليس بمقياس

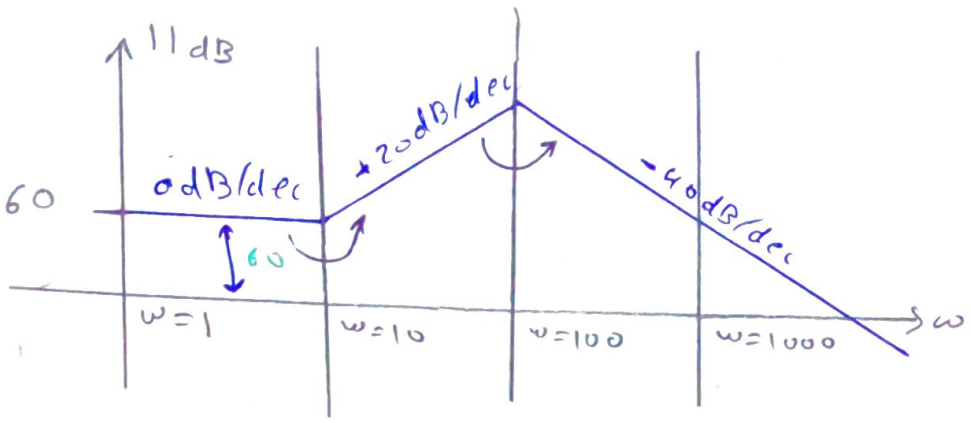
$$PM = 180 + \phi(\omega_{0.5})$$

$$= 112.57 \quad , \quad GM = \infty$$

$\Rightarrow$ stable

النظام مستقر

Ex:



find the O.L.T.F G H(S)

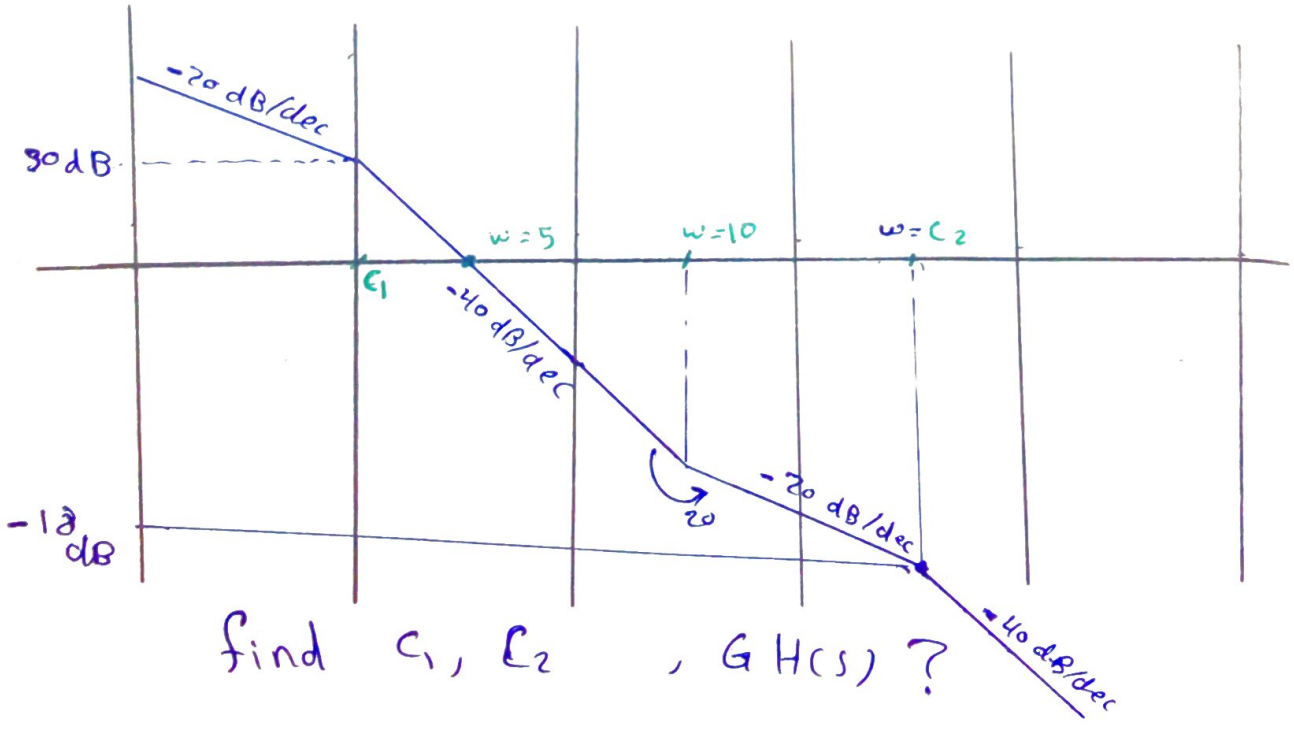
$$GH(S) = \frac{K\left(1+\frac{S}{10}\right)}{\left(1+\frac{S}{100}\right)^3}$$

$$20 \text{ Log } K = 60 \Rightarrow K = 10^3 = 1000$$

$$GH(S) = \frac{1000\left(1+\frac{S}{10}\right)}{\left(1+\frac{S}{100}\right)^3}$$

Report: يسلم في المحاضرة

اوجد GH(S) و C_1, C_2



find C_1, C_2, GH(S) ?

$$GH(s) = \frac{K\left(1+\frac{s}{T_0}\right)}{s\left(1+\frac{s}{C_1}\right)\left(1+\frac{s}{C_2}\right)}$$

الحل من خلال حل معادلات أو الرسم على ورق

semi-log

(ويفضل استخدام الرسم والحل لأنه أسهل)